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BEFORE THE

U. S. HOUSE OF REPRESENTATIVES

COMMITTEE ON TRANSPORTATION & INFRASTRUCTURE

SUBCOMMITTEE ON RAILROADS

HEARING ON

HUMAN FACTOR ISSUES IN RAIL SAFETY

July 25, 2006

I appreciate your invitation to brief this Subcommittee on the current status of railroad Hours of Service regulations and the opportunities to further improve the management of employee fatigue and safety in US railroads. I have had the opportunity to witness the considerable improvements in railroad fatigue management and safety over the past 30 years, both as the Chairman and CEO of Circadian Technologies, Inc. ("CIRCADIAN"), www.circadian.com, a research and consultancy firm which has extensive experience in developing and implementing fatigue management programs for railroads and other round-the-clock industries, and as a professor of physiology at Harvard Medical School where I led the initial research programs which identified the biological clocks that control human cycles of alertness and sleep.

We all applaud the 50% reduction in human factor-caused accidents per million train miles since 1980, but also need to be sobered by the realization that this human error rate has remained essentially at a fixed plateau since 1985. Freight trains move more freight further and faster than ever before, and with ever increasing efficiency and automation. Since 1990 the number of trillion ton miles of freight moved on US railroads has increased by 56% while freight railroad employment has decreased by 25%. Each employee now moves more than double the ton miles of freight each year than they did in 1990, so the need for sustained employee attention and alertness while operating trains and maintaining track must be a paramount objective.

The freight railroads were early adopters of the science of fatigue management and have emphasized to a greater extent than perhaps any other industry the goal of assuring human alertness around-the-clock in their 24/7 operations. This is not a casual observation since CIRCADIAN has worked in virtually every 24/7 industry on all seven continents of the globe, and based on this experience, the US railroads stand out in their clearly stated commitment to fatigue management.

Specifically CIRCADIAN, and other fatigue management consultants and researchers, have collaborated with many of the major railroads including Amtrak, BNSF, Union Pacific, CSX, Conrail, Canadian National, and Canadian Pacific as well as the unions, including the Brotherhood of Locomotive Engineers and the United Transportation Union.

Together we have developed, implemented and scientifically evaluated a wide variety of fatigue countermeasure strategies.

So the question must be asked: Why have railroad human factor-caused accidents remained at a plateau despite the continued emphasis on fatigue management? Two possibilities can be quickly ruled out. Firstly, it is not because fatigue no longer exists. As any confidential survey of railroad employees will tell you, sleep disruption and fatigue continues to be a major concern of railroad employees. Secondly, it is not because fatigue no longer causes accidents. Despite advances in automation, fatigue-induced lapses in attention and cognitive behavior remain a significant cause of railroad accidents and injuries.

The answer instead, in my opinion, is that fatigue management to date has been more a process of measuring inputs rather than outputs. Fatigue education programs have been delivered, sleep disorder screening initiated, napping and other policies implemented, and various changes in work schedules proposed and tested. A large number of these efforts have been widely reported, and some research on their benefits has been published. However the relationship between these fatigue management initiatives (inputs) and <u>bottom-line</u> objective measures of effectiveness -- such as human factor-caused accidents per million train miles (outputs) has not yet been assessed or demonstrated.

At the core of the problem is the structure of the Hours of Service laws which date way back into fatigue management pre-history. As I will discuss, there is abundant evidence that the railroad Hours of Service laws which were put into place in 1908, almost 100 years ago, offer little hope for preventing fatigue, and furthermore they unduly restrict the business operations of the railroads and negatively impact the lives of rail employees. But most importantly the HoS emphasis on compliance with a set of prescriptive rules keeps the railroad industry in an outdated paradigm.

In contrast, I believe there is much more promise in a **Fatigue Risk-Informed Performance-Based Safety** management approach as a creative and effective tool for addressing this vital safety issue. The principle is that if railroads measure and monitor the specific risks, then government regulators can require the operators of the regulated industries to focus their attention and creative energy on ways to reduce those specific risks, without prescribing cumbersome rules on the exact interventions by which the safety goal should be met.

The evolution of Risk-Informed, Performance-Based safety management

Recent years have seen the evolution of a new regulatory paradigm which replaces deterministic rules, laws and regulations. This paradigm focuses on the measurement of risk, so that performance in meeting objective risk reduction goals can be measured and assessed. Managing by performance-based measure is a well-established method of obtaining tangible results in a business, as is removing some controls but enhancing accountability (see Hertzberg[1]). What is new is applying these concepts to government safety regulations, and allowing managers in the regulated industry the flexibility to find the solutions which achieve safety objectives within their own operations.

The Risk-Informed Performance-Based (RIPB) approach to safety management is probably most advanced in the nuclear power industry, although it has been applied to Fire Prevention[2], nuclear waste disposal[3] and the design of security and blast mitigation at Federal Buildings[4]. The Nuclear Regulatory Agency has made a significant effort to

[1] Herzberg GF, Mausner B, Snydeman BB. The motivation to work. New York: Wiley; 1959.

[2] Federal Register. Vol. 69, No. 115, Wednesday, June 16, 2004/ Rules & Regulations “Voluntary Fire Protection Requirements for Light-Water Reactors: Adoption of NFA 805 as a Risk-Informed, Performance-Based Alternative” p. 33536.

[3] Mackin PC, Russell B, Turner DR, Ciocco, JA. Implementing risk-informed, performance-based regulations for high-level waste disposal. Paper presented at the Waste Management Symposium, Tucson, Arizona, February-March 2001. www.wmsym.org/Abstracts/2001/31B/31B-20.pdf

[4] National Research Council (U.S.) Committee to Review the Security Design Criteria of the Interagency Security Committee. ISC security design criteria for new federal office buildings and major modernization projects: a review and commentary. Washington, DC: The National Academies Press; 2003.

convert to this method of regulation and it now permeates every aspect of nuclear power safety regulation. As the Nuclear Energy Institute reports[5]:

> "In a risk-informed performance-based approach, the NRC establishes basic requirements and sets overall performance goals. The plant management then decides how to reach those goals. Risk-informed, performance based regulation is more sharply focused on safety than the current approach, because resources are applied to plant systems and equipment commensurate to their importance to safety"

For example, after working with the National Fire Protection Association (NFPA), the NRC published an NPRM and then a final rule on June 16, 2004 concerning a RIPB program for voluntary fire protection standards for nuclear power plants. This program allowed for fire protection measures that are based on a more realistic assessment of the actual fire hazard in various areas of a power plant than was assumed in the previous requirements[58].

This alternative results-driven process has now been systematically adopted by the Nuclear Regulatory Commission to regulate the myriad safety aspects of nuclear power plants, placing the responsibility on nuclear plant operators to find the most effective way to get the desired safety outcomes, rather than the NRC writing excessively complex and unmanageable prescriptive regulatory rules which are insensitive to local operating conditions or technology.

Application of Fatigue Risk-Informed Performance-Based Safety to other transportation modes

We have now five years of experience in applying the Fatigue Risk-Informed Performance-Based Safety (FRIPBS) paradigm to fatigue management in trucking

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[5] Nuclear Energy Institute. Nuclear Power Plant Regulation. 2001. www.nei.org/documents/Status_Report_Regulation.pdf

operations. The results have been dramatic in reduced accident rates per million miles and reduced personal injuries per 200,000 hour worked.

The process started with the development and validation of a Circadian Alertness Simulator (CAS) model which predicts not only levels of fatigue risk (as a fatigue Risk Score) but also the rate of DOT recordable accidents.

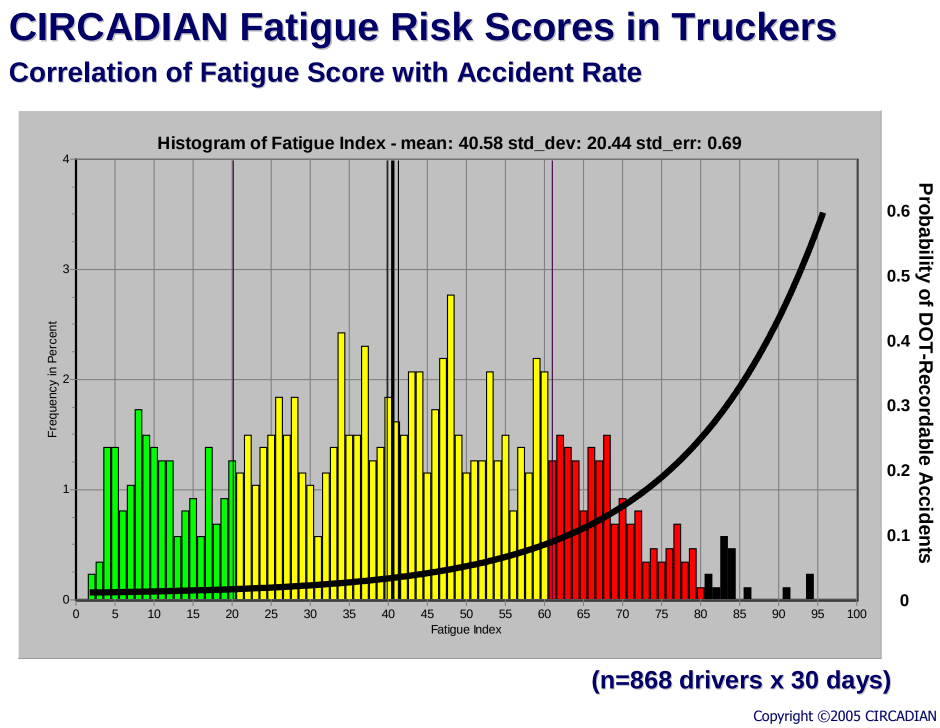

Fig 1. Each driver is assigned a fatigue-risk score between 1 (low risk) and 100 (high risk) which is calculated from his duty-rest pattern over the prior week. While the average fatigue risk score of US truck drivers is approximately 40 there is a wide frequency distribution of risk scores. The superimposed line is the probability of a DOT recordable accident per year with the risk rapidly rising as fatigue scores exceed 60-70. At a fatigue risk score of 90, for example, a driver has a 50% probability of having a DOT recordable accident in the next year.

The application of FRIPBS to truck driver fatigue management is illustrated in Figure 2. Information on the actual truck-driver Hours of Rest are continuously captured (from driver logs or in this case electronically using telematics) and entered into an Expert System for calculating Fatigue Risk in truck drivers. A “Fatigue Score” for each driver in the fleet is provided to the driver, his dispatcher and the operations and safety managers making them “Risk-Informed”. Training programs are provided to these individuals to educate them in the principles of driver Flexible Sleep Management and the

"Performance-Based" standards of Fatigue score management. Based on the training and the repetitive feedback from the Fatigue Scores, the driver seeks to minimize his Fatigue Score by adopting flexible sleep management practices, and is monitored and is held accountable to these "Performance-Based" standards by his dispatchers and managers.

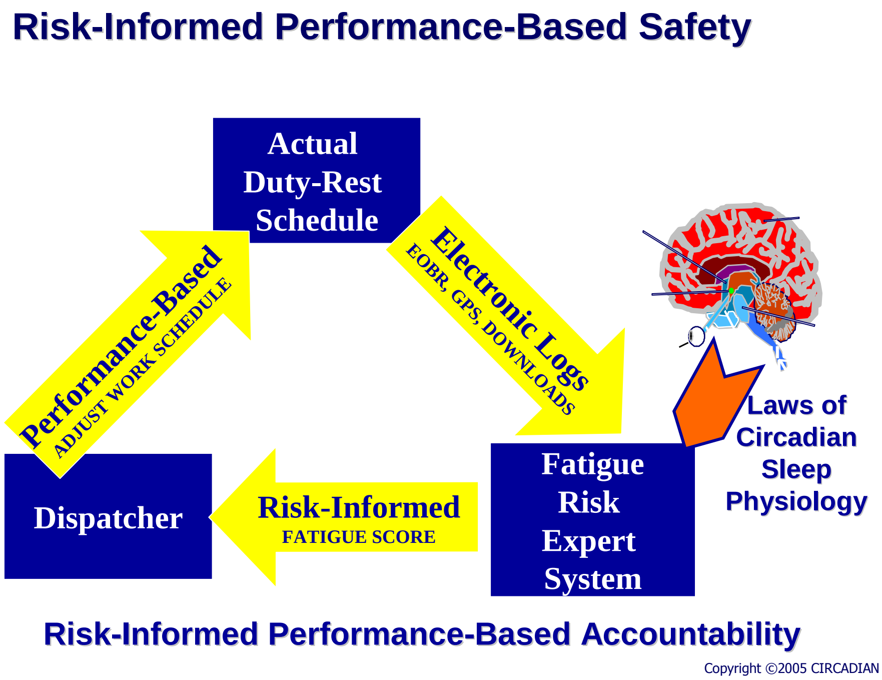

Fig 2: The feedback loop whereby the Fatigue Risk Score for each driver is calculated from his Hours of Rest pattern and provided to each driver (and his manager and dispatcher) so they are "Risk-Informed". The driver (and/or dispatcher in a scheduled operation) is then held accountable to meet a Performance-Based risk standard by adjusting his future Hours of Rest patterns which then are recalculated to track progress against meeting Fatigue Risk management objectives.

This Fatigue Risk-Informed Performance-Based Safety approach to duty-rest regulation and fatigue management enables drivers, dispatchers and managers to make safety conscious operational decisions while having sufficient flexibility to balance the specific business needs of their operation (e.g. optimization of customer service, minimization of operational costs) and therefore stay competitive in the marketplace. At the same time they have the incentive to address some of the most important causes of driver sleep deprivation, and therefore of fatigue-related highway accidents.

In addition because this FRIPBS process is automated and documented, it reduces the burden of compliance enforcement and log book inspections by the states. The focus of

FRIPBS compliance is shifted from input parameters (Hours of Service) to output parameters (Fatigue Risk Score & accident risk) which is where the true burden of safety management should lie.

Not only did the mean Fatigue Score (Fig 3) progressively decrease as the management trained the drivers and held them accountable for reducing their Fatigue Scores, but even more importantly there was a substantial left shift of the distribution of Fatigue Scores so very few drivers were operating in the highest CAS Fatigue Score zones where there is disproportionately greater risk of accidents and injuries occurring.

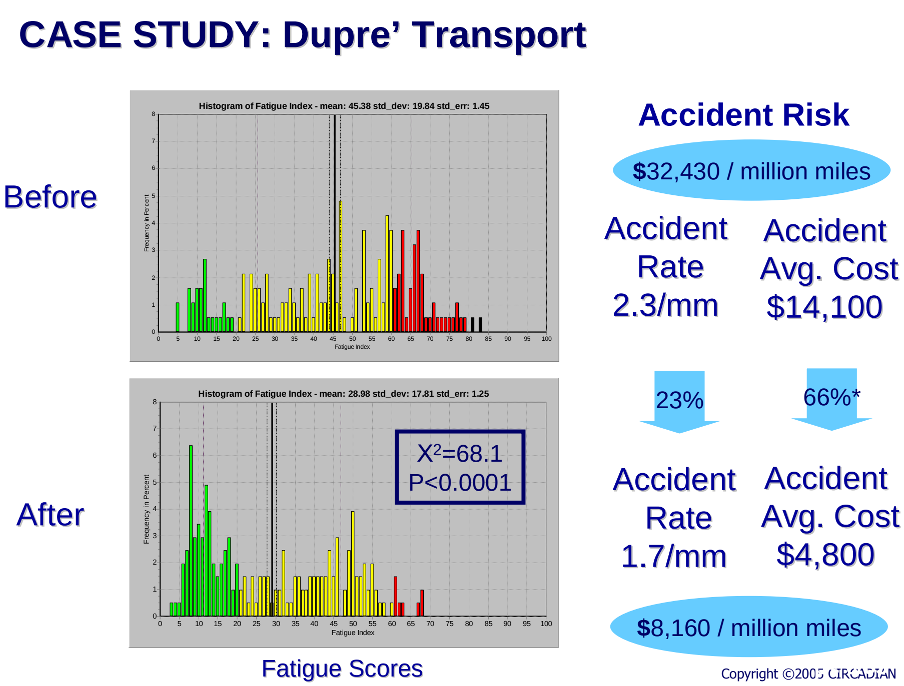

Fig. 3. Frequency distribution of CAS Fatigue Scores and accident rates and costs for drivers before (above) and after (below) the RIPB intervention where CAS Fatigue Scores were provided as feedback back to dispatchers and managers. Fatigue Score group averages are indicated by vertical lines. A significant reduction in both fatigue scores, and the frequency and severity of accidents was observed.

The reduction in CAS Fatigue scores as a result of the FRIPBS program correlated with a parallel decrease in accidents, personal injury and driver turnover in the truck drivers. Figure 4 shows the decrease in the “Big Four” accidents most likely to be associated with driver lapses of attention while on the road. These were Rollovers, Rear-End Collisions, Lane Change accidents and Intersection Accidents. The accident rate of 1.29 per million miles found in the base years (1998-2001) fell to 0.9 in 2001-2002, to 0.8 in 2002-2003 and to 0.5 in 2003 – 2004.

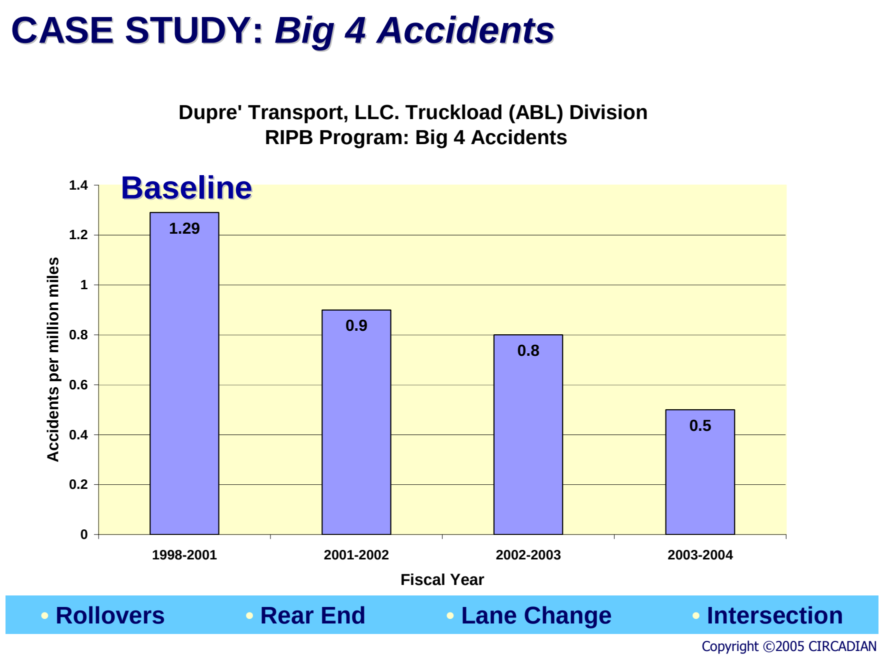

Fig 4. Comparison of the Big Four accident rate for truck drivers (Rollovers, Rear End, Lane Change, Intersection) before (three baseline years 1998-2001) and during three years of implementation (2001-2002, 2002-2003, and 2003-2004) of a FRIPBS Fatigue Management program with CAS Fatigue Score feedback to the drivers and dispatchers who were held accountable for minimizing the CAS scores.

I wish to propose that this Sub-Committee consider lending its full support and endorsement to a process which requires every railroad and their unions to jointly work towards developing, implementing and filing Fatigue Management Plans with the Federal Railroad Administration. These should demonstrate that each American rail operator is reducing fatigue risk through a process which is “Risk Informed” and “Performance Based.” By “Risk Informed,” I refer to the continuous objective assessment of fatigue risk across all operations; by “Performance-Based,” I mean holding management and employees personally accountable for achieving measurable fatigue risk reduction.

Experience has taught us that excessive fatigue risk is manageable and preventable, but not by the traditional regulatory Hours of Service (HoS) approach. The issue of employee fatigue in transportation operations led in the early 1900's to the development of the HoS concept, which used a rudimentary "hour-glass" model of human fatigue: namely that after a certain number of consecutive hours on duty, or cumulative hours in a week, a person becomes fatigued. Over the past 30 years the science of human fatigue (sleep-wake, alertness & circadian physiology) has moved ahead rapidly, but regulatory reform has lagged behind. It is now broadly accepted that, while HoS can prevent some extreme abuses, under this "hour-glass" fatigue model of current HoS, an employee can be perfectly legal but unsafe, or illegal and perfectly safe. It is not enough to point to HoS compliance and claim that fatigue has been successfully managed.

First, HoS regulations fail to consider the well-established fact that nighttime work poses a higher risk than daytime work. Many studies have shown that the most consistent factor influencing operator alertness is time of day. Similarly, daytime sleep is not as restful as nighttime sleep so the efficiency with which off-duty time can be used for rest varies with the time of day.

Second, the total number of consecutive hours of work, or total accumulated hours of work in a week do not have a simple relationship with fatigue risk, except in extreme circumstances. For example while a person who works more than 60 hours a week may in certain circumstances become sleepy and risk falling asleep at the controls, at other times of the same day he would have very little likelihood of falling asleep. Similarly a person only working 10 or 20 hours a week, depending on what time of day he is at the controls, may be just as much as risk for fatigue as the person who worked more than 60 hours a week. Indeed one of the most common scenarios for fatigue-related accidents is the first few hours on night duty after a vacation or weekend off-duty, which should be a time of lowest risk according to the hour-glass HoS fatigue model. Yet, this time of enhanced risk is clearly predicted by fatigue risk models based on current science.

Third, the HoS does little to address the problem of unpredictable work. The flow of freight trains across a railroad system fluctuates from hour to hour, because of weather, mechanical failures, and track damage or repairs. Duty rest schedules are therefore hard to predict on a day-to-day basis, especially when labor agreements also allow other crewmembers to book off-duty, and hence accelerate the sequence of call to duty. The quality of sleep is significantly reduced during on-call situations where there is anticipation that sleep may be disrupted.

Finally, HoS regulations typically encourage operators to adopt work/rest schedules that are shorter than 24 hours. For train crews, for example, the most “productive” work/rest schedule is a duty–rest cycle consisting of successive periods of 11 ¾ hours running a train followed by the minimal 8 hours rest period, resulting in 20-hour work-rest cycles. This results in disruption of circadian rhythms, encourages employees to work when they are tired, and often obliges them to rest when they are not. Moreover, the direction of the rotation will be “backwards” since the cycle is shorter than the natural 24-hour day. There is extensive scientific data demonstrating that backward rotations are more fatiguing than forward rotations.

Building more complex prescriptive HoS regulations that take these physiological safety factors into account is not the answer. The regulations would have to be so complex as to be unmanageable due to the multiple factors that must be taken into account. It would severely impact the competitiveness and business operations of the railroad industry and potentially negatively influence the lives and earnings of the unionized crafts.

The method of choice to immediately and effectively address the issue of railroad employee fatigue, which I propose that this committee actively encourage and endorse, is a process of Risk-Informed Performance-Based Fatigue Management.

Significant advances have been made in the development and validation of effective fatigue countermeasures in railroad operations in the past 10 years. Railroads, more than any other transportation mode, have expended considerable resources to advance the science of fatigue management. These include the development of training programs, work-rest scheduling systems and crew scheduling software, napping policies and sleep disorder screening programs, each of which in scientific studies has been shown to reduce fatigue.

However, the full benefits from this fatigue research have not yet been obtained because the application of these fatigue countermeasures across the railroad industry has to date been limited and inconsistent. Furthermore adequate measures have not been implemented for documenting results and effectiveness on an ongoing basis, or for holding managers accountable.

There is now an opportunity to make substantial gains in transportation safety, but the achievement of this will not be without its challenges. 175 years of railroading tradition, and a complex thicket of regulations and collective bargaining agreements can sometimes make progress difficult. However, I know all parties view fatigue reduction and rail safety as important, so there is support for the overall goal.

This Subcommittee can do much to stimulate and motivate this process. I would propose that the House Railroad Subcommittee encourage railroad companies, and the railroad labor unions, to make the development of a formal process for Risk-Informed Performance–Based Fatigue Management a priority. An overall strategy should be developed that is sensitive to all stakeholders that could form a framework for future reform of rail safety legislation. A timetable for reporting back progress to this subcommittee might be helpful in ensuring that addressing this key railroad safety issue is maintained as a priority.

In summary, I have today discussed how sleep deprivation and fatigue significantly impairs train crew alertness and vigilance in our railroads, and that this loss of vigilance poses a safety threat. Moreover, FRA safety statistics suggest that the human factor-caused accident rate has plateaued over the past 20 years, and such a status quo is not acceptable. However, making the Hours of Service regulations more restrictive is clearly not the best answer to fixing the problem. Faced with today's challenges, a Fatigue Risk-Informed Performance-Based Safety management approach is best positioned to provide measurable benefits in a timely and efficient manner. I appreciate the opportunity today to share my thoughts and suggestions with this Sub-Committee, and I would be delighted to answer any questions.